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ABSTRACT

This report includes a capsule description of changes in science achievement, as part of the National Assessment study of changes in science achievement for 9-year-olds, 13-year-olds, and 17-year-olds attending schools. Concrete information is presented in the progress or decline of knowledge in science. It is reported that knowledge of fundamental scientific facts and principles has declined among American students. Data reported are based on an estimate of the percentage of individuals in a given age population who responded acceptably to a given question. To assess the growth or decline in attainment on a given question, the difference between performance in 1969-70 and 1972-73 was obtained. National results by age level are reported. Also presented is how groups of individuals responded to certain exercises. The groups are characterized by age, sex, race, region of the country, level of parental education, and size and type of community. A brief section includes putting the data into perspective. (Author/EB)

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NATIONAL ASSESSMENT OF SCIENCE, 1969-1973

SE 019 015

NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS
A Project of the Education Commission of the States

Arch A. Moore, Jr., Governor of West Virginia, Chairman, Education Commission of the States
Wendell H. Pierce, Executive Director, Education Commission of the States
J. Stanley Ahmann, Director, National Assessment

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1969–70 Assessment

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7	Results by color, parental education, size and type of community; balanced results, May 1973	2.60

Citizenship

2	National Results, November 1970	1.70
6	Results by sex, region and size of community, July 1971	1.25
9	Results by color, parental education, size and type of community, May 1972	2.85

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NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

NATIONAL ASSESSMENTS OF SCIENCE, 1969 and 1973

A Capsule Description of Changes in Science Achievement

Science Report No. 04-S-00

February 1975

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NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

J. Stanley Ahmann
Director

George H. Johnson
Associate Director

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TABLE OF CONTENTS

LIST OF EXHIBITS v

FOREWORD vii

PREFACE ix

ACKNOWLEDGMENTS xi
ANAC Membership, 1965 to the Present xi

INTRODUCTION xiii

NATIONAL RESULTS 1
Results by Age Level 1

NATIONAL ASSESSMENT REPORTING VARIABLES AND GROUP RESULTS 5
Reporting Variables 5
Group Results 6

PUTTING THE DATA INTO PERSPECTIVE 13

LIST OF EXHIBITS

EXHIBIT 1. Distribution of Changes in Performance in Science for 9-Year-Olds, 1970—73 2

EXHIBIT 2. Distribution of Changes in Performance in Science for 13-Year-Olds, 1969—72 2

EXHIBIT 3. Distribution of Changes in Performance in Science for 17-Year-Olds Enrolled in School, 1969—73 3

EXHIBIT 4. National Assessment Geographic Regions 5

EXHIBIT 5. An Example of Change in Southeast Performance on One Exercise 7

EXHIBIT 6. Average Regional Changes in Performance at Ages 9, 13 and 17 9

EXHIBIT 7. Average Changes in Performance for Males and Females at Ages 9, 13 and 17 10

EXHIBIT 8. Average Changes in Performance for Blacks and Whites at Ages 9, 13 and 17 11

EXHIBIT 9. Average Changes in Performance for Selected Size and Type of Community (STOC) Groups at Ages 9, 13 and 17 12

FOREWORD

The National Assessment of Educational Progress (NAEP) is an information-gathering project which surveys the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds and adults (ages 26—35) in 10 learning areas: art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. At least one area is assessed every year, and all areas are periodically reassessed in order to measure educational progress. Each assessment is the product of several years work by a great many educators, scholars and lay persons from all over the country. Initially, these people design objectives for each area, proposing general goals which they feel Americans should be achieving in the course of their education. These goals are reviewed by more people and then passed along to developers of tests, whose task it is to create measurement tools appropriate to the objectives.

When the exercises prepared by the test developers have passed extensive reviews by subject-matter specialists and measurement experts, they are administered to probability samples of various populations. The people who comprise those samples are chosen in such a way that the results of their assessment can be generalized to an entire national population. That is, on the basis of the performance of about 2,500 9-year-olds on a given exercise, we can generalize about the probable performance of all 9-year-olds in the nation. Approximately 100,000 persons participate annually.

After assessment data have been collected, scored and analyzed, National Assessment publishes reports to present the results as accurately as possible. Not all exercise results are released for publication. Because NAEP will administer some of the same exercises again in the future to determine whether the performance level of Americans has improved or declined, it is essential that they be kept secret in order to preserve the integrity of the study. If the unreleased exercises can be discussed without revealing their content, they are examined. However, the discussion is much less detailed than it is for the released exercises.

The National Assessment of Educational Progress also publishes a *General Information Yearbook* which describes all major aspects of the assessment process. This volume defines the categories by which results are reported and elaborates on the scientific procedures utilized. The reader who desires more detailed information about how National Assessment defines its groups, prepares and scores its exercises, designs its sample and analyzes and reports its results should consult *General Information Yearbook, Report 03/04-GIY* which is available, as are all Assessment reports, through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

PREFACE

When the United States Office of Education was founded in 1867, one charge set before its commissioner was to determine the nation's progress in education. Only recently has that century-old charge been addressed in a systematic way. It is being done by the National Assessment of Educational Progress (NAEP).

Each year since 1969 NAEP has gathered census-like information about levels of educational achievement across the country and reported its findings to the nation. During the first five years of its endeavors, National Assessment has interviewed and tested more than 400,000 representative young Americans. Baseline data on the achievement levels of young Americans in eight learning areas—science, social studies, music, literature, reading, writing, mathematics and citizenship—have been collected and reported.

This report, *National Assessments of Science, 1969 and 1973: A Capsule Description of Changes in Science Achievement*, summarizes the National Assessment study of changes in science achievement for 9-year-olds, 13-year-olds and 17-year-olds attending schools. Having assessed achievements in science twice, NAEP can now report to the American public concrete information on the progress or decline of knowledge in science. This report is only a very brief summary of the information NAEP has gathered. Future reports will provide more complete documentation and discussion of these and other results.

ACKNOWLEDGMENTS

Assessing changes in the science achievement of young Americans throughout the nation is an undertaking of major proportions. Certainly it could not become a reality without substantial contributions by a great number of people, not the least of whom are the students, teachers and administrators who made the effort possible to begin with. Unfortunately, it is not possible to acknowledge all the important contributions to the Assessment, and an apology is due to those whose names have been omitted.

Original preparation of the objectives and exercises in the science area was completed by the Educational Testing Service (ETS). Dozens of consultants—both subject-matter specialists and lay persons—reviewed these materials under the general guidance of the National Assessment of Educational Progress (NAEP) staff. Administration of exercises was handled by the Research Triangle Institute (RTI) and the Measurement Research Center (MRC). Scoring and processing were carried out by MRC and by NAEP staff members.

Special acknowledgment must go to Dr. Ralph W. Tyler; to the Analysis Advisory Committee (ANAC) of National Assessment, which developed the details of the plan for measuring change; and especially to the Science Panel of ANAC (SPANAC) chaired by Dr. John Tukey of Princeton University, which has initiated or reviewed all of the analysis procedures used to report changes in levels of achievement. Without their consistent support and advice, both on technical and general matters, this endeavor could not have come to pass.

ANAC Membership, 1965 to the Present

Frederick Mosteller, chairman since 1973. Professor of mathematical statistics, Harvard University (1970—).

John W. Tukey, chairman 1965—73. Professor of statistics, Princeton University (1965—).

Robert P. Abelson, professor of psychology, Yale University (1965—72).

David R. Brillinger, professor of statistics, University of California at Berkeley (1973—).

William E. Coffman, professor of education, University of Iowa (1970—).

Lee J. Cronbach, professor of psychology and education, Stanford University (1965—69).

James A. Davis, director of National Opinion Research Center, Chicago, Illinois (1973—).

Janet Dixon Elashoff, statistical advisor, Center for Advanced Study in the Behavioral Sciences, Palo Alto, California (1973—).

John P. Gilbert, staff statistician at the Harvard University Computer Center (1970—).

Lyle V. Jones, professor of psychology, L.L. Thurston Psychometric Laboratory, dean of the graduate school, University of North Carolina (1965–).

Lincoln E. Moses, professor of statistics, dean of the graduate school, Stanford University (1974–).

Ralph W. Tyler, Science Research Associates, Chicago, Illinois (1965–69).

The preparation of this report was a collaborative effort of the National Assessment staff. Special thanks must go to the following people: David Lyon and Ingrid VanRoyen of the Data Processing Department; Ava Powell, Robert Larson and Susan Sherman of the Research and Analysis Department; and to Robert Crane of the Utilization/Applications Department, who wrote this report.

J. Stanley Ahmann
Project Director

INTRODUCTION

Knowledge of fundamental scientific facts and principles has *declined* among American students. A comparison of the results for the *1969–70* national science assessment and the *1972–73* national science assessment indicates that 9-year-olds, 13-year-olds and 17-year-olds tend *not to perform as well as they did three to four years ago.*

Although suspicions have been growing among scientists and nonscientists alike that public knowledge of and interest in science has declined in recent years, until now there has been no national data that could either substantiate or refute these suspicions. The initial national assessment of science took place in 1969–70. The second one was administered in 1972–73.[1] These represent the first comprehensive assessment of the educational attainments of Americans in science ever attempted and provide concrete information about changes in the levels of knowledge of American youth between 1969 and 1973.

In the first National Assessment (NAEP) study in 1969–70, 9-year-olds, 13-year-olds and 17-year-olds attending school (age levels which mark the end of primary, intermediate and secondary education) were asked a variety of questions designed to measure achievement of four broad educational objectives in science. These objectives are (1) that Americans should know some fundamental facts and principles of science; (2) that they should possess some abilities and skills needed to engage in the process of science; (3) that they should understand the investigative nature of science; and (4) that they should have some attitudes about science and appreciate its role in the culture. Approximately one half of the questions asked in 1969–70 were repeated in 1972–73. Using the same exercises again in a controlled manner, NAEP was able to measure the increase or decline in attainment between the two science assessments.

[1] The assessment schedule varied for each age level. The actual administration dates were:

9-year-olds	Jan.–Feb. 1970	Jan.–Feb. 1973
13-year-olds	Oct.–Dec. 1969	Oct.–Dec. 1972
17-year-olds	March–May 1969	March–May 1973

NATIONAL RESULTS

The data reported by the National Assessment of Educational Progress (NAEP) are based on an estimate of the percentage of individuals in a given age population who would respond acceptably to a given question. To assess the growth or decline in attainment on a given question, the difference between performance in 1969–70 and 1972–73 was obtained. For example, 13-year-olds were asked the following question in the two assessments.

Which of the following diseases is known to be transmitted by an insect?

- ○ *Cancer*
- ○ *Diabetes*
- ● *Malaria*
- ○ *Measles*
- ○ *Polio*
- ○ *I don't know.*

In 1969, 84.6% of the 13-year-olds correctly identified malaria; however, only 77.0% of the 13-year-olds did in 1972. In 1972, 7.6% fewer 13-year-olds answered the question acceptably than did so in 1969. Put another way, the change from 1969 to 1972 was -7.6%. Given that there are approximately 3.6 million 13-year-olds in the population, a 7.6% drop would mean that approximately 270,000 fewer 13-year-olds would successfully answer the question.

At any given age level, the differences in the percentage of respondents who answered a question acceptably for the two assessments were calculated and collected into a distribution. The distribution represents the full range of differences for that age level and is a comprehensive representation of changes in performance. For the sake of simplicity, however, this report will focus upon the *average* difference as an indicator of overall performance.[1] Since it is easy to understand, the average is a useful number to use when summarizing the change in performance for a given age level on a large number of questions.

Results by Age Level

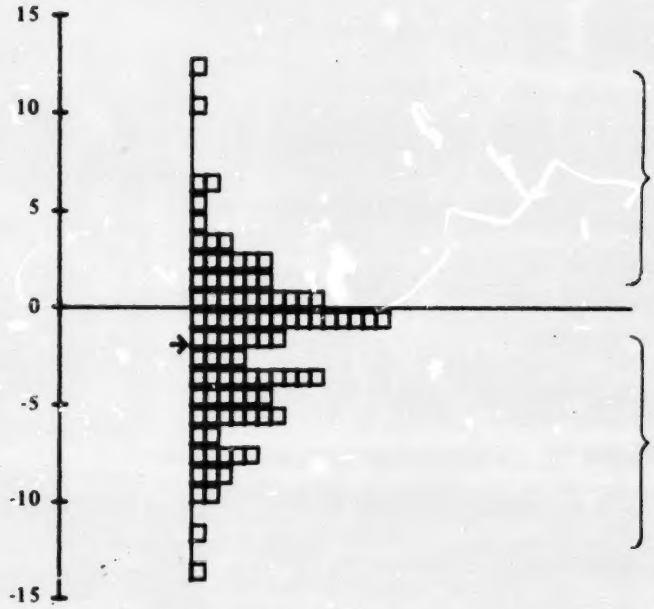
Age 9

Ninety-four questions asked of 9-year-olds in the first science assessment were asked of 9-year-olds again in the second science assessment. In general, the performance of 9-year-olds tended to decline. On 31, or approximately one third, of the questions more 9-year-olds answered correctly in the second assessment. However, on two thirds (63) of the questions fewer 9-year-olds answered correctly. The average performance (indicated by the arrow) declined 1.8%. This 1.8% drop suggests that an estimated 65,000 fewer 9-year-olds would answer a typical science question correctly in 1973 than would have done so in 1970. Exhibit 1 illustrates the complete distribution of changes at age 9, indicating that fewer 9-year-olds acceptably answered NAEP science questions in 1973 than did so in 1970.

---

[1] In the following discussion of results, the term average performance is used to represent the arithmetic mean or what is commonly called the average. It is the sum of percentages of success for each exercise divided by the number of exercises.

EXHIBIT 1. Distribution of Changes in Performance in Science for 9-Year-Olds, 1970–73

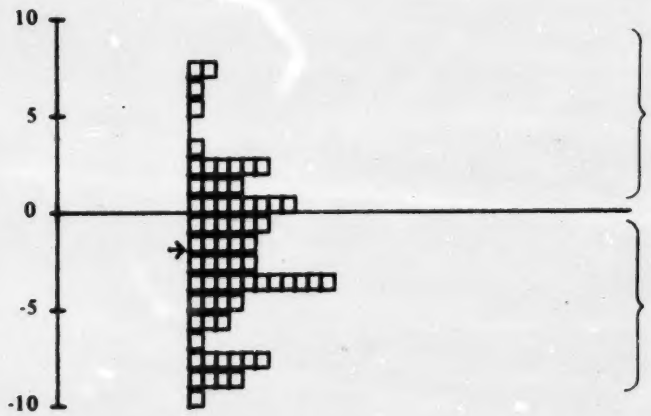


On 31 questions, more 9-year-olds could answer correctly in 1972 than in 1970.

On 63 questions, fewer 9-year-olds could answer correctly in 1973 than in 1970.

Each box represents the change in performance on one science exercise.

EXHIBIT 2. Distribution of Changes in Performance in Science for 13-Year-Olds, 1969–72



On 23 questions, more 13-year-olds could answer acceptably in 1972 than in 1969.

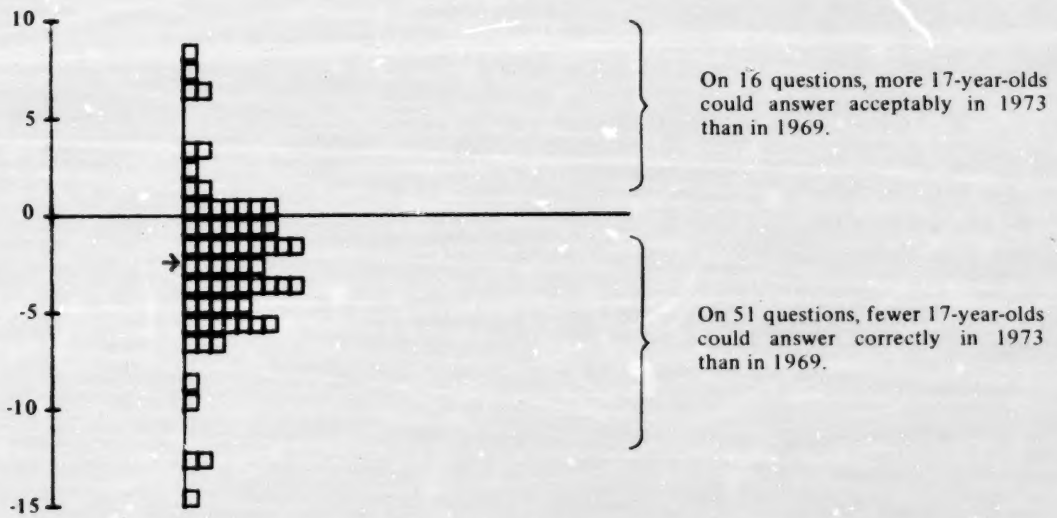
On 46 questions, fewer 13-year-olds could answer acceptably in 1972 than in 1969.

Each box represents the change in performance on one science exercise.

Age 13

Sixty-nine questions asked of 13-year-olds in the first science assessment were repeated in the second assessment. In general, the performance of 13-year-olds, like that of 9-year-olds, tended to decline. On 46 of the 69 questions, 13-year-olds showed declines in performance; however, on 23 of the questions more 13-year-olds answered acceptably in the second assessment than did so in the first assessment. The average performance (indicated by the arrow) declined 1.9%. This suggests that an estimated 70,000 fewer 13-year-olds would have responded acceptably to a typical science question in 1972 than would have in 1969. Exhibit 2 illustrates the complete distribution of changes for 13-year-olds.

EXHIBIT 3. Distribution of Changes in Performance in Science for 17-Year-Olds Enrolled in School, 1969–73


10
5
0
-5
-10
-15
On 16 questions, more 17-year-olds could answer acceptably in 1973 than in 1969.
On 51 questions, fewer 17-year-olds could answer correctly in 1973 than in 1969.

Each box represents the change in performance on one science exercise.

Age 17

Sixty-seven questions, asked of 17-year-olds enrolled in school in 1969, were repeated in the second science assessment. In general, fewer 17-year-olds answered questions correctly in 1973 than did so in 1969. On 51 questions, 17-year-olds showed declines in performance; however, on 16 questions more 17-year-olds answered acceptably in the second assessment than had done so in the first assessment. The average performance (indicated by the arrow) declined 2.3%, suggesting that an estimated 80,000 fewer 17-year-olds would have responded acceptably to a typical science question in 1973 than would have in 1969. Exhibit 3 shows the complete distribution of changes for 17-year-olds, illustrating the slight decline in performance between the first and second assessments. The impact of this decline is lessened when one considers that it reflects change over a four-year period compared to three years at ages 9 and 13.

NATIONAL ASSESSMENT REPORTING VARIABLES AND GROUP RESULTS

Reporting Variables

The National Assessment of Educational Progress (NAEP), unlike most testing programs, does not report scores for individuals.[1] Rather, it reports how defined *groups* of individuals respond to certain exercises. The groups are characterized by age, sex, race, region of the country, level of parental education and size and type of community (STOC).

[1]More detailed information on the methodology employed by NAEP can be found in the *General Information Yearbook, Report 03/0. GIY* (Washington, D.C.: Government Printing Office, 1974). Specific chapters on sampling, objectives and exercise development, administration, data processing and analysis procedures can be found in this volume.

The groups discussed in this capsule description are defined as follows.[2]

Region

The students have been divided into four groups, each representing a region of the country—Southeast, West, Central and Northeast—as shown in Exhibit 4.

[2]Some group results are not discussed in this capsule description. Data are also collected for respondents who are neither black nor white within the variable color; for the highest level of parental education attained by either of a respondent's parents from no high school through post high school; and for medium cities, small places and urban fringe within the variable size and type of community. These groups will be discussed in later reports.

EXHIBIT 4. National Assessment Geographic Regions

Sex

Results are presented separately for males and for females.

Color

Results are presented for blacks and whites.

Size and Type of Community (STOC)

The groups within this variable are defined by the size of the community in which a student's school is located and an occupational profile of the area the school serves.

Low metro. People (about 10% at each age level) in this group attend schools serving areas in which a high proportion of the residents are on welfare or not regularly employed; these schools are in cities with populations greater than 150,000.

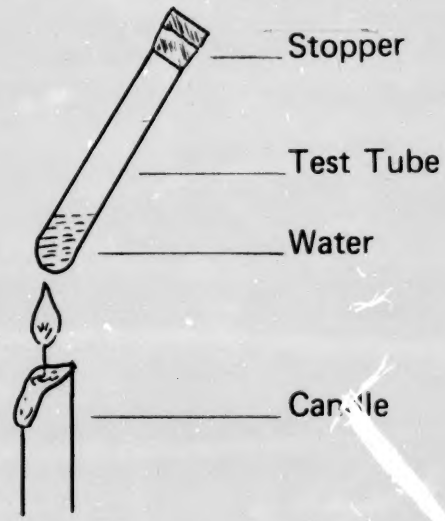
Extreme rural. Students (about 10% at each age level) in this group attend schools in a community where most residents are farmers or farm workers, and the population is less than 3,500.

High metro. Individuals (about 10% at each age level) in this group attend schools within the city limits or residential area served by a city with a population greater than 150,000; many residents of the area served by the school are professional or managerial personnel.

Main big city. These are students (about 11% at each age level) attending schools in a big city (population greater than 200,000) who are not included in either the low metro or high metro groups.

Group Results

Each group's percentage of success is compared to the percentage of success obtained for the national sample. The difference between these two percentages indicates how well a group is performing in relation to the nation as a whole. For example, the following exercise was given to 13 year-olds in 1972.



Water is heated as shown in the diagram above. If the stopper pops out, which of the following is most important in accounting for this?

- ○ *The stopper gets hot and expands.*
- ● *Some of the water is changed to steam.*
- ○ *The air in the test tube absorbs heat.*
- ○ *The glass test tube gets very hot and starts to melt.*
- ○ *The glass test tube expands more than the stopper.*
- ○ *I don't know.*

In the high metro group 54.8% of the 13-year-olds answered this exercise correctly compared to 52.2% of all the 13-year-olds. The difference between these two percentages (54.8% - 52.2%) is 2.6%. Since the national percentage of success is always subtracted

from the group percentage, a positive difference means that the group is performing at a level better than the national level of performance; a negative difference means that the group is not performing as well as the nation. In this case, +2.6% means a higher proportion of high metro 13-year-olds knew the answer to this question than 13-year-olds nationally.

Changes in group performance are measured by changes in the percentage of success for that group and by changes in the group's position relative to the nation. By observing these two changes we can determine, first, whether a larger or smaller proportion of respondents answered a question correctly in 1972—73 than in 1969—70 and, second, whether or not there was a change between the assessments in the group's standing relative to the nation as a whole. Both types of information contribute to an understanding of how the performance of a given group has changed. The following example illustrates the types of change information group results provide.

This question was asked of 9-year-olds in 1970 and again in 1973.

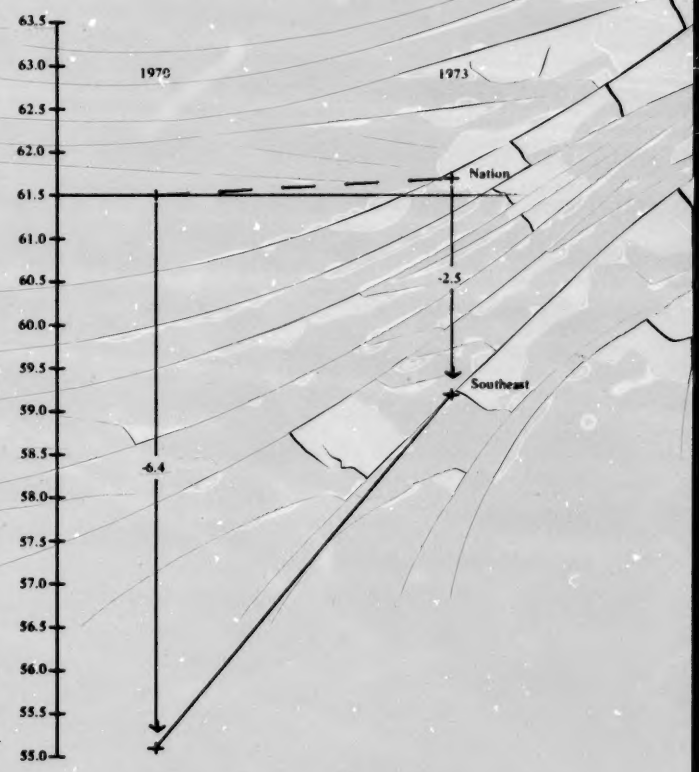
Putting sand and salt together makes

- ○ *a chemical.*
- ○ *a compound.*
- ○ *an element.*
- ● *a mixture.*
- ○ *a solution.*
- ○ *I don't know.*

In the first science assessment 61.5% of the 9-year-olds answered this question acceptably. By comparison only 55.1% of the Southeastern 9-year-olds did so. Subtracting the national percentage (61.5) from the Southeastern percentage (55.1) leaves a group difference of -6.4. In other words, 6.4% fewer Southeastern 9-year-olds than 9-year-olds nationally knew that putting sand and salt together makes a mixture.

When asked the identical question in 1973, 61.7% of the 9-year-olds nationally answered the question correctly compared to 59.2% of the Southeastern group. In this instance, the difference between the Southeast and the nation was -2.5%. That is, 2.5% fewer Southeastern 9-year-olds than 9-year-olds nationally gave the correct answer. Exhibit 5 presents the relative position of Southeastern 9-year-olds and the nation on this question in both assessment years. The national performance level in 1970 (61.5%) serves as the point of reference on the graph. The Southeast performance in 1970 is plotted at 55.1%. The national level of performance in 1973, 61.7%,

EXHIBIT 5. An Example of Change in Southeast Performance on One Exercise



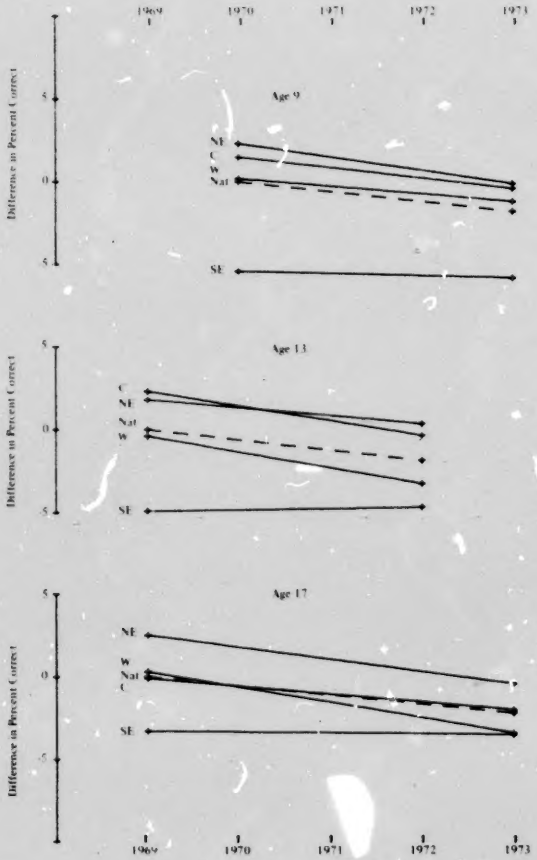
is plotted above the baseline performance established in 1970. The Southeast performance in 1973, 59.2%, is plotted 2.5 points below the national level in 1973.

Although Southeastern performance on this exercise was still below the national level in 1973, there was considerable improvement relative to Southeastern achievement in 1970. The gap between national performance and the performance of Southeastern 9-year-olds had appreciably narrowed between the assessments.

While changes in group performance on individual questions are informative and interesting, a comparison of the average performance for a given group in the first assessment with the average performance of the same group in the second assessment is a more useful indicator of the general performance trend of that group. Exhibits 6 through 9 display the average performance levels of National Assessment groups in both assessment years. The relative position of the groups in 1969–70 and the average national performance level are shown on the left side of the graph. Average group performances are plotted above and below the national level. The average national level of performance and average group performance in 1972–73 are shown on the right-hand side. The slope of the line depicts the direction and rate of change in performance between the first and second science assessments.

Exhibits 6, 7, 8 and 9 indicate that most of the groups performed less well in the second assessment than they had in 1969. Only a few groups improved. For example, the extreme rural and Southeastern groups did improve relative to the nation between 1969 and 1973. If the trends they exhibited should continue, these groups could reach national levels of performance in less than a decade.

EXHIBIT 6. Average Regional Changes in Performance at Ages 9, 13 and 17

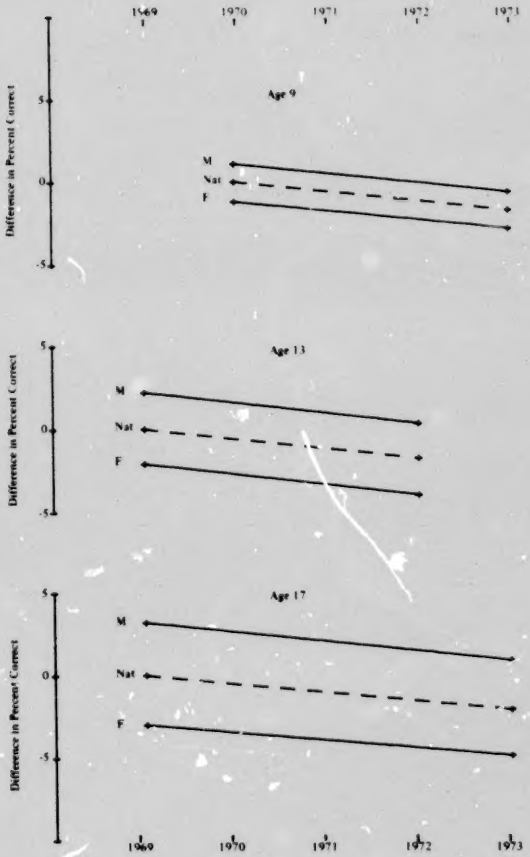


While Northeastern, Central and Western performance levels all declined, Southeastern performance remained about the same or showed a slight improvement. Considering that the nation as a whole declined, the Southeastern results are more impressive. Western performance declined most noticeably except at age 9.

KEY:

NE – Northeast
C – Central
W – West
SE – Southeast

EXHIBIT 7. Average Changes in Performance for Males and Females at Ages 9, 13 and 17

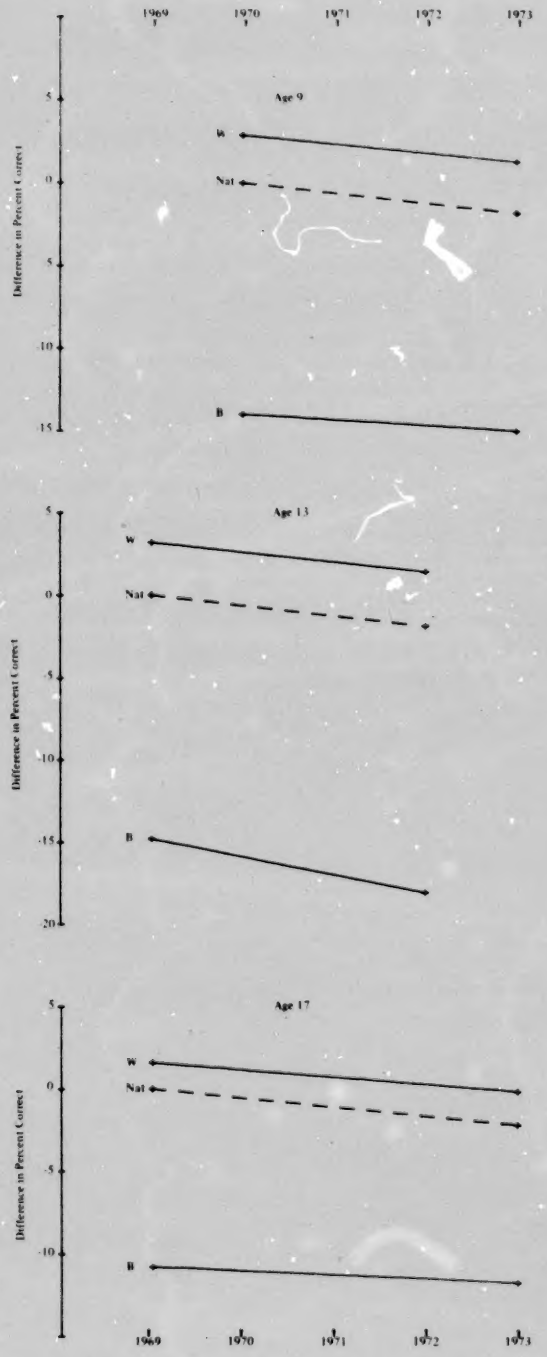


The percentages of males and females that answered a typical science question correctly declined at all three age levels. Furthermore, the gap between males and females remained constant. The performance of 9-year-old boys is, on the whole, 2 to 3% above that of girls. The average performance of 13-year-old boys is still 4% above that of girls. At age 17, average male performance is 6% above that of females.

KEY:

M – Male
F – Female

EXHIBIT 8. Average Changes in Performance for Blacks and Whites at Ages 9, 13 and 17

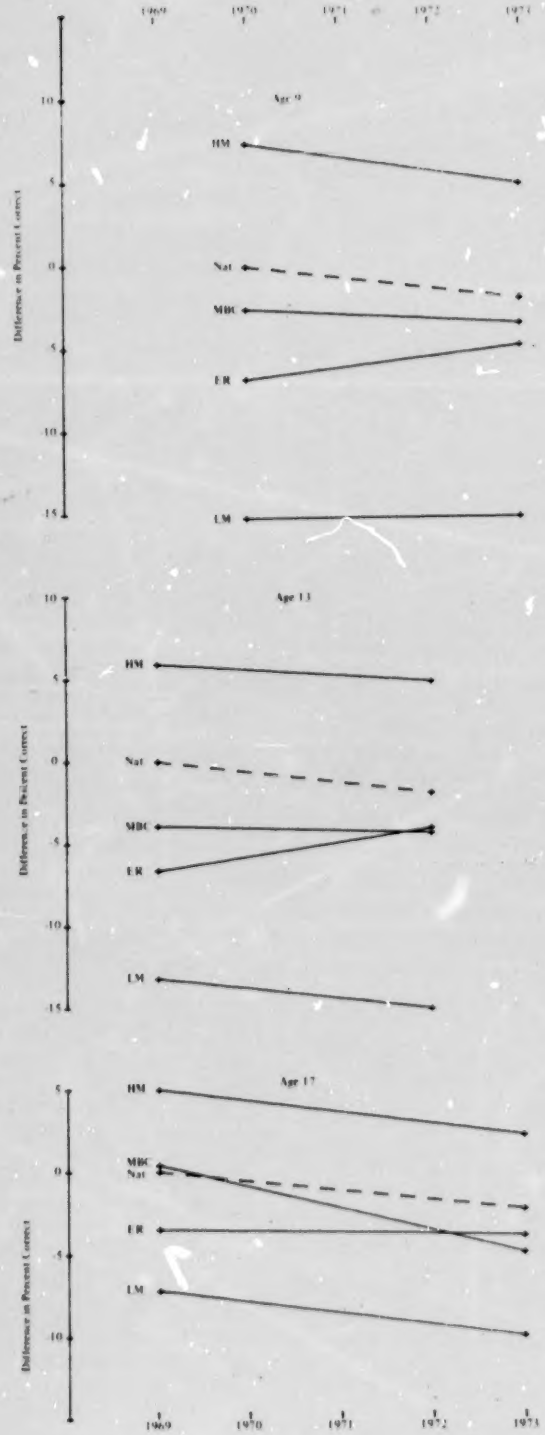


The gap between the performance of black and white 9-year-olds remained about the same between 1970 and 1973. At age 13 this gap increased slightly. Black 13-year-olds declined somewhat more than the nation as a whole. The gap between the performance levels of white and black 17-year-olds remained about the same between 1969 and 1973.

KEY:

W – White
B – Black

EXHIBIT 9. Average Changes in Performance for Selected Size and Type of Community (STOC) Groups at Ages 9, 13 and 17



The percentage of rural students that could answer a typical science question correctly increased noticeably at all three ages. Low metro areas are well below the nation and are not improving. At age 17, main big city students showed the greatest declines, dropping from just above the national level to well below. High metro students at all three age levels continued to perform above the national level, although they are declining at about the same rate as the nation.

KEY:

HM – High metro
MBC – Main big city
LM – Low metro
ER – Extreme rural

PUTTING THE DATA INTO PERSPECTIVE

The average decline in science achievement at all three ages between 1969—70 and 1972—73 was about 2 percentage points. Identical science exercises given at more than one age level in the same assessment generally show an average gain of 4% per year of age in the proportion of respondents able to answer acceptably. Thus, this average decline of 2 percentage points in the proportion of students answering science questions would appear to correspond to the loss of a half year of learning experience.

A number of factors might account for declines in science achievement between 1969—70 and 1972—73. The decline in the number of young Americans demonstrating knowledge in science may simply reflect the fact that fewer students are electing to take science courses. It is possible that achievement levels may be rising among those students enrolled in science curricula; the National Assessment of Educational Progress (NAEP) assessed *all* students at these age levels, not just those interested in science. Teachers may well be doing a better job than ever with a select group of students who will form the nucleus of the next generation's scientific community.

Perhaps the results of the science assessment are satisfactory and as expected. Quite possibly less attention is being paid to science in the schools these days; the declines between 1969 and 1973 may only suggest that unusual emphasis was given to science education in the wake of "Sputnik," and the new results reflect a return to more normal achievement levels. On the other hand, our society is becoming more technological and complex, and this may be a poor time for such a decline. Average citizens must have some basic knowledge about science to remain informed about critical social and environmental issues upon which they are expected to make rational decisions. Can the average citizen know too much science, given the complexity of the world that confronts us? Should the general public be encouraged to appreciate science for its own virtues? Are we training enough good scientists to meet the growing needs of our technological society? Should scientists and science educators attempt to make science more relevant to the social and political concerns of both majority and minority Americans? The public at large should join the scientific and educational communities in discussing these issues.

Education is the largest single enterprise in the United States today. Three out of every 10 Americans are directly involved in the educational process, and expenditures have more than doubled in the last decade, with an estimated $54 billion being spent for elementary and secondary education in 1971 alone.[1] A great deal of effort has gone into improving the educational system. Yet, at least in science, there was a general decline in the knowledge levels of American youth between 1969—70 and 1972—73. Furthermore, the gap between national and group performance in science has not been narrowed for females, black Americans or students from low metro schools. The facts highlighted in this report should stimulate discussions about national interest in science, school responsibility for science education and the long-term implications of a downward trend in science achievement.

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[1] W. Vance Grant, "Education's New Scorecard," *Selected Statistical Notes on American Education*, DHEW Publication No. (OE) 73-111703 (Washington, D.C.: Government Printing Office, February 1973), pp. 3—8.

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